

NPDGamma Led Calibration

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1 Introduction

Inside of the CsI detectors in the NPDGamma detector array there are leds. These leds are to be used as a test of the vacuum photo diodes that is independent of the CsI scintillator. This will help distinguish between changes in the scintillator and changes in the vacuum photo diode. In each detector there are two leds. One on the side of the crystal that is upstream on the beam (front led) and one on the side of the crystal that is downstream on the beam (back led). Both set of leds (front and back) are wired to there own break-out box so that they may be powered independently. Inside of the breakout box is a board on which a resister is wired in series with the led. The 48 resister/led pairs are in turn wired in parallel with each other.

2 Calibration

Initially, all of the leds were wired with $100\ \Omega$ resistors. A test of this setup performed by turning on the leds and running the DAQ, showed that there was so much variation in led brightness that they exceeded the dynamic range of the DAQ as evidenced by the fact that most of them fell along one of two lines. One of the lines was about 10% above the average and the other was about 10% below the average. These 10% lines are approximately the limits of the dynamic range of the DAQ.

One hypothesis as to why there was so much variation in the brightness was that the voltage being supplied was very close to the turn on voltage of the leds. If this was the case the leds would be in a very nonlinear region and small variations in the leds could lead to big differences in brightness. As an attempt at correcting this problem, the $100\ \Omega$ resistors were changed to $1500\ \Omega$ resistors, the theory being that this would allow us to turn up the power supply to get away from this very volatile region. The leds were tested again in the same manner with a very similar result. Turning up the power made it possible to get closer to the desired brightness of about 3 V out of the preamplifier, but the variations still exceeded the dynamic range of the DAQ. Thus, it was decided that it would be necessary to tune a resistance specifically for each led.

In deciding how to provide each led with a specific resistance, two possibilities were considered. First, the use of potentiometers was considered, the advantage being that one could tune in the exact resistance needed to make all leds equal in brightness as well as the fact that they could be easily adjusted later. However, the board had been designed only for resistors and there was not room for a potentiometer for each channel. The other possibility was to pick a specific fixed resistor for each led. This would only be possible if the leds stayed relatively

constant and would not require adjustment at a latter time. After a few days of monitoring a few of the leds, it was noted that they drifted by at most 100 mV in 3000 mV. Based on this, it was determined that it was worth trying to pick a specific resistor for each led.

The resistance need to make all of the leds equal in brightness for a give power supply setting was measured. The variation found was so large that many new resistors needed to be ordered. Since it was not perfectly clear that the leds would be stable enough for this approach to be effective, it was desirable not to spend money and time on a parts order. Thus 2 or 3 of the available resistors were used in parallel to make up the desired resistances. The measured needed resistance, resistors used, measured resistance after constructing the circuit, and the percent error from that resistance needed, are shown in Appendix B. Resistors were selected with the goal of keeping the error under 3%.

3 Results

After wiring the resistors, the stability of the front leds was monitored for about a month (see data in Appendix C). With a few exceptions noted in the following paragraphs, the drift of the leds was small compared to the dynamic range of the DAQ. The output stayed within about the middle half of the available range. After about a month of observing acceptable drift of the front leds, the board for the back leds was made using the resistance values that had been measured a month earlier. Again, with a few exceptions noted below, the leds had remained constant to an acceptable level over the month's time (see data in Appendix D).

While most leds were very stable, a few problems were found. First, an inexplicable drift was seen in the front led data for detector 2-6 (channel 17, with channels numbered starting at 0). The resistor was retuned and again it drifted out of the range. The resistor was retuned again and it has stayed within the range since. When the back leds were tested, the back led in the same detector had left the dynamic range. Thus, there may be a coincidence of two bad leds, there may be drift in the detector itself, or, although this was checked with no problems found, there could still be bad cables or connections.

Another inconsistency was occasionally seen in the front led of detector 4-3 (channel 38). In a few runs it provided an abnormally bright reading, but when checked a few hours later it was again providing the correct value and no problem could be found with the resistors or the cables.

Finally, a problem was noted with back led 4-10 (channel 45). This appears to be a bad spot in the cable or the connector where it connects to the breakout box. When the cable is shaken the led turns on and off. When checked on another connection on the breakout box, the behavior is still seen which eliminates the box as a source of the problem.

4 Conclusion

Since unexplained abnormalities were seen in only 3 out of 96 leds over a month's time, two of them being in the same detector, it seems that the leds will remain stable enough for the fixed resistors to be successful.

APPENDICES

Appendix A

Led Data Sheet

Appendix B

This appendix shows the data used to select the resistors (The values used initially are shown first changes are on the fourth page of this appendix). The first page is for the front leds. The columns, in order, show: Detector number, Resistance needed to make the leds equal, the first resistor used, the resistance needed for the second resistor given the first, the second resistor used, the calculated equivalent resistance, the error between the equivalent resistance and the needed resistance, the measured resistance after the circuit was assembled, and the error between the measured resistance and the needed resistance.

The second page provides the same information for the back leds, however, for some of the back leds a third resistor was needed and that data appears on the third page.

The fourth page is a list of changes made after the initial setup.

Appendix C

In this appendix are lists of data and graphs showing the front led readings. In the data lists, the first column is the detector number, the second column is the average value, the third and fourth columns are approximately the top and bottom saturation points of the DAQ respectively. The graphs show a scatter plot of the output from each detector with the leds on and the power source set to 6.75V. The vertical axis is mV output and the horizontal axis is detector number. At the top of the graph, the date that the data was taken is noted.

Appendix D

This appendix provides the same information for the back leds as that provided for the front leds in Appendix C.